



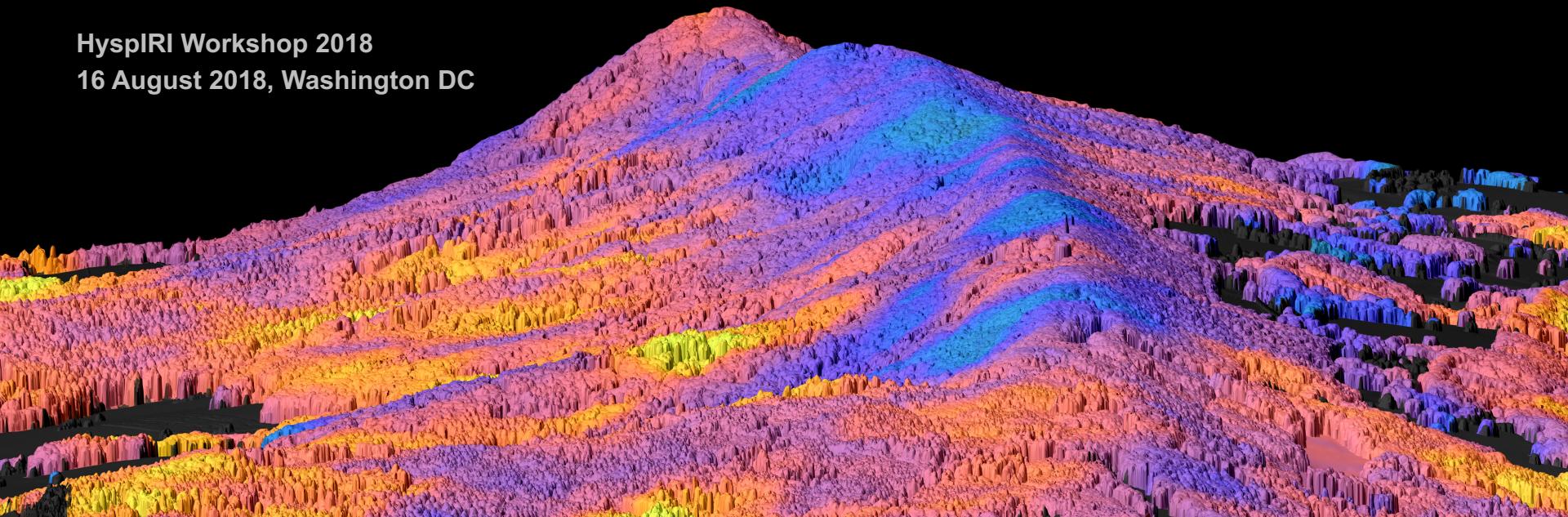
**Jet Propulsion Laboratory**  
California Institute of Technology

# Mapping plant diversity from space and using it to inform ecosystem models

FD Schneider, ME Schaepman, P Moorcroft, F Morsdorf, P Townsend, R Pavlick, DS Schimel

HyspIRI Workshop 2018

16 August 2018, Washington DC



# Biodiversity-Productivity Relationship

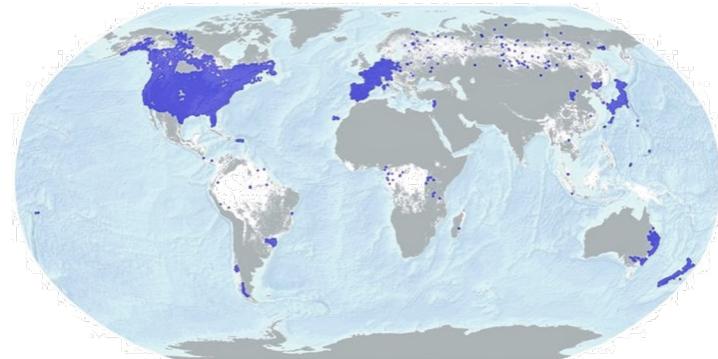
Plant diversity as indicator for ecosystem health, stability and functioning

RESEARCH ARTICLE

FOREST ECOLOGY

## Positive biodiversity-productivity relationship predominant in global forests

Jingjing Liang,<sup>1\*</sup> Thomas W. Crowther,<sup>2,3†</sup> Nicolas Picard,<sup>4</sup> Susan Wiser,<sup>5</sup> Mo Zhou,<sup>1</sup> Giorgio Alberti,<sup>6</sup> Ernst-Detlef Schulze,<sup>7</sup> A. David McGuire,<sup>8</sup> Fabio Bozzato,<sup>9</sup>

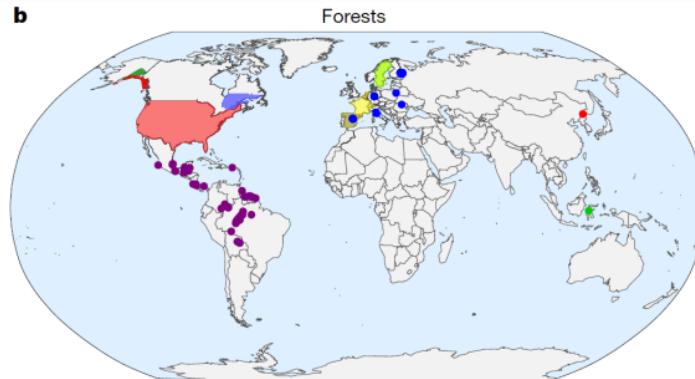


LETTER

doi:10.1038/nature23886

Biodiversity effects in the wild are common and as strong as key drivers of productivity

J. Emmett Duffy<sup>1</sup>, Casey M. Godwin<sup>2</sup> & Bradley J. Cardinale<sup>2</sup>

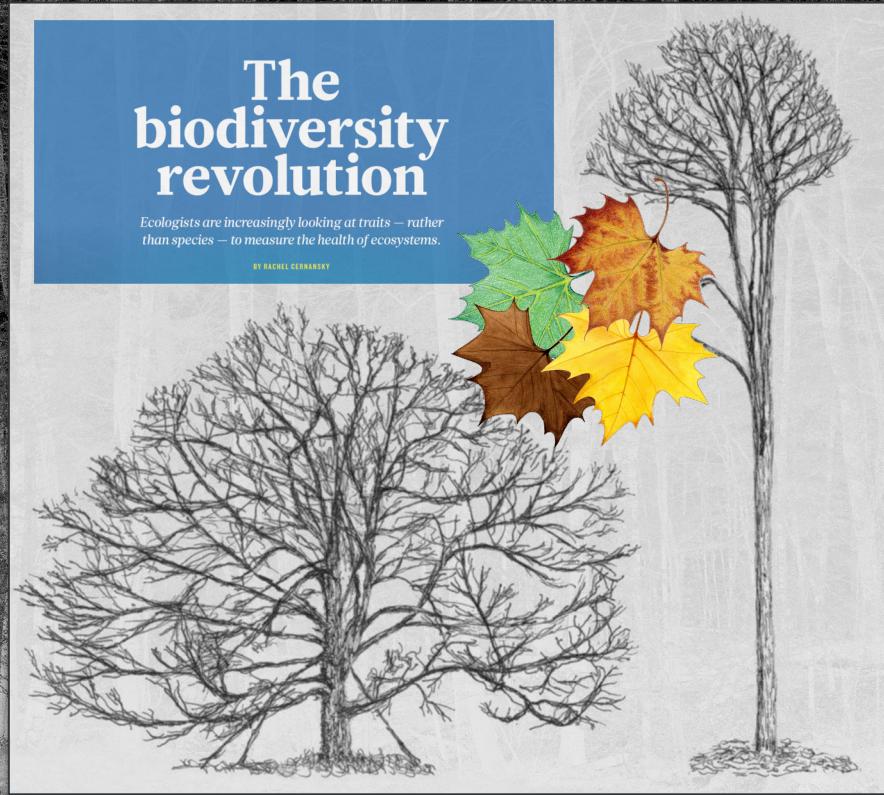


# How do we measure Biodiversity?

Remote Sensing of Plant Functional Traits

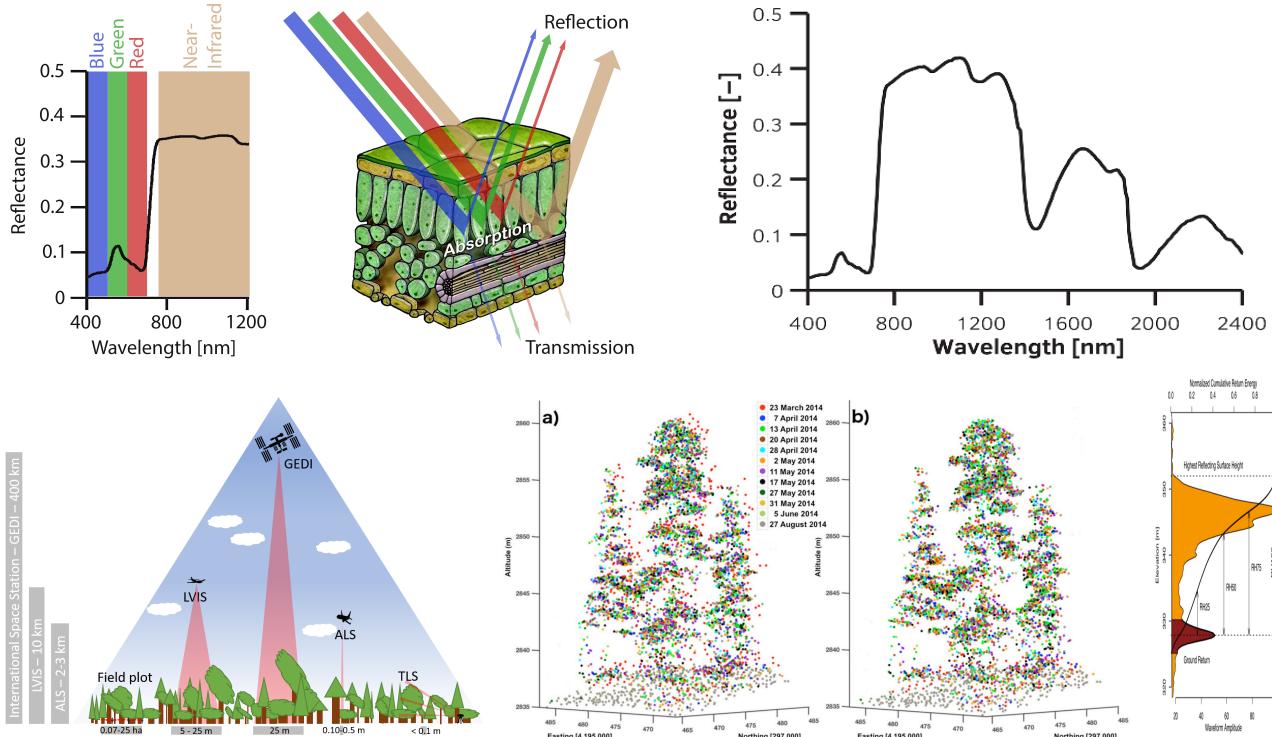


**“Just going for species numbers doesn’t allow us to harness all this incredibly rich information of how the real world operates.”**



# Methods to Measure Traits

## Imaging Spectroscopy and Laser Scanning



Schaepman, et al. (2015) RSE; Lee, et al. (2015) RSE; Schneider, et al. (2014) RSE; Ferraz, et al. (2018) RS

**APEX**  
400 – 2500 nm  
@3-14 nm and 2 m

**AVIRIS Classic**  
400 – 2500 nm  
@10 nm and 15 m

**Airborne LiDAR**  
30 cm Footprint  
5-40 pts per m<sup>2</sup>

**Spaceborne LiDAR**  
25 m Footprint  
10-30 pts per km<sup>2</sup>

# Test Case in Switzerland

Small-Scale Airborne Data at Individual Tree Level

# Canopy Morphological Traits

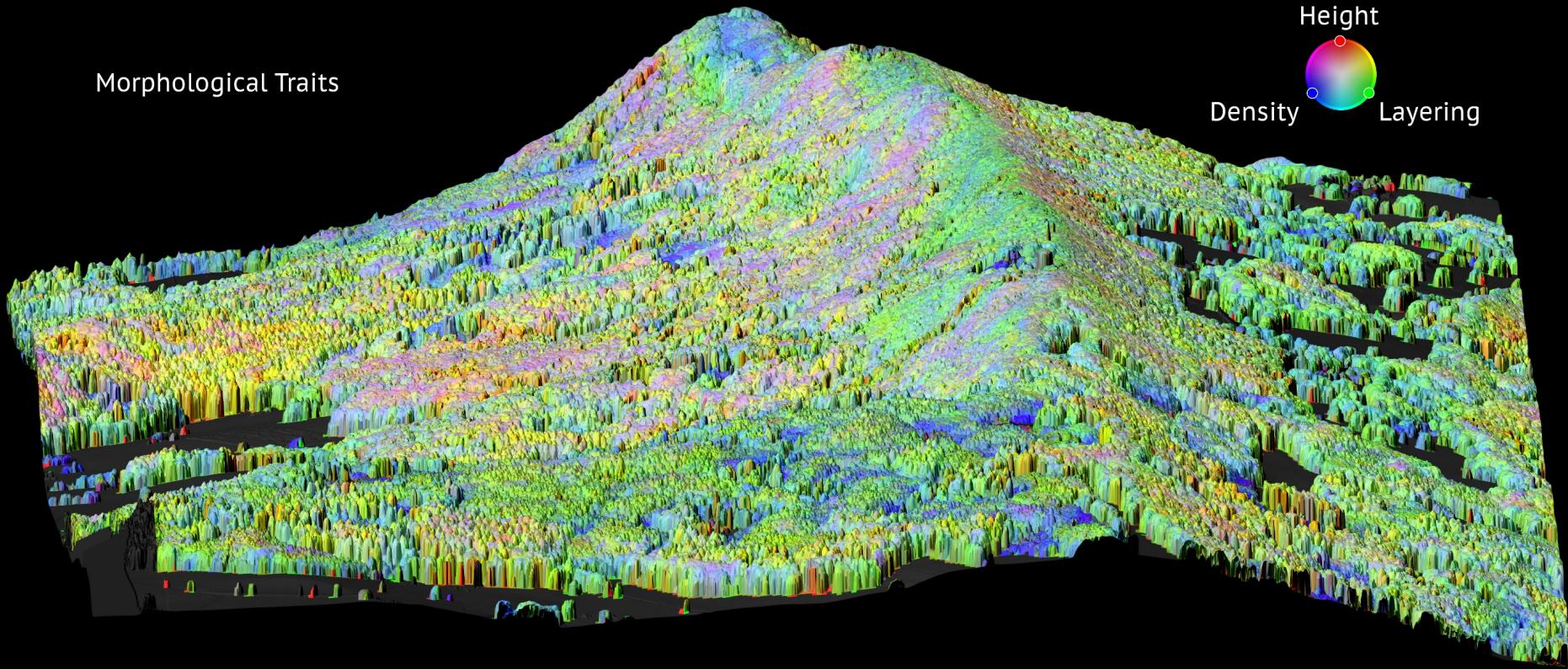
Morphological Traits

Height



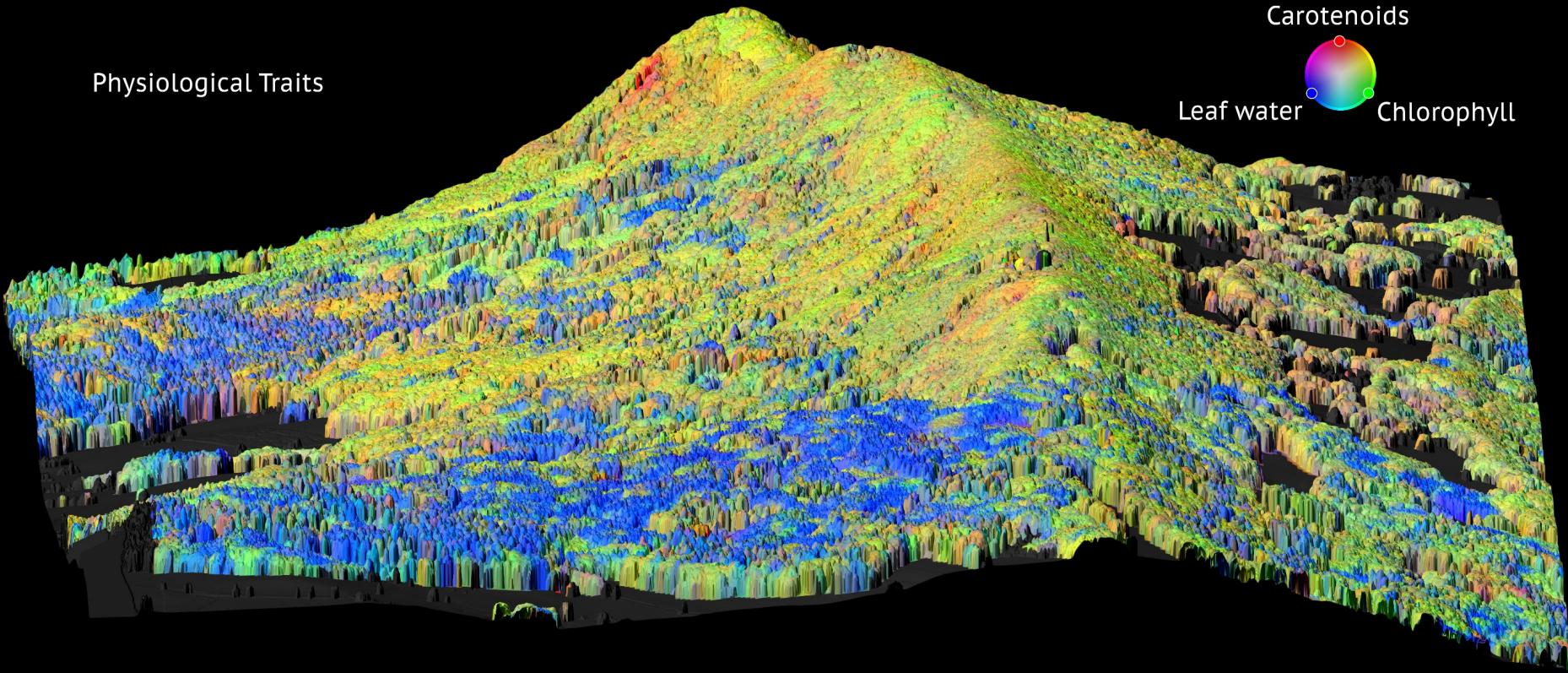
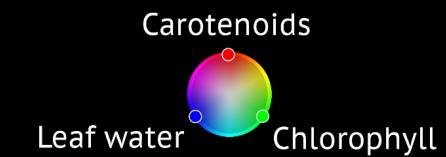
Density

Layering



# Leaf Physiological Traits

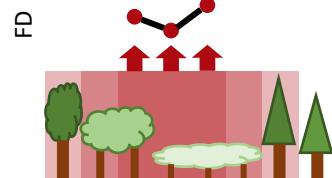
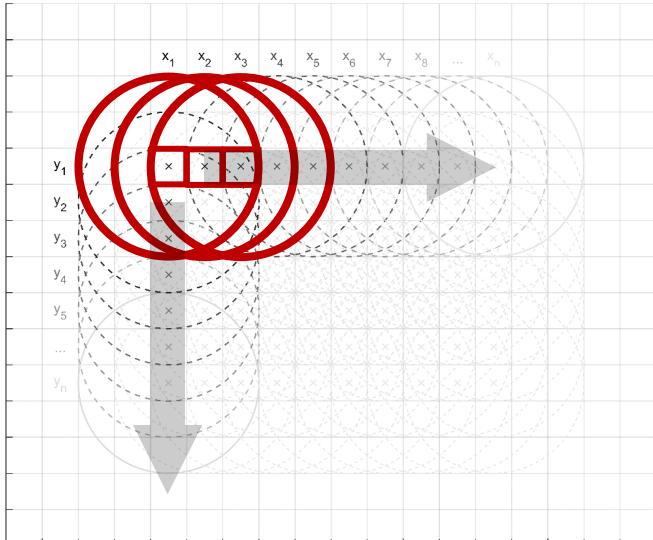
Physiological Traits



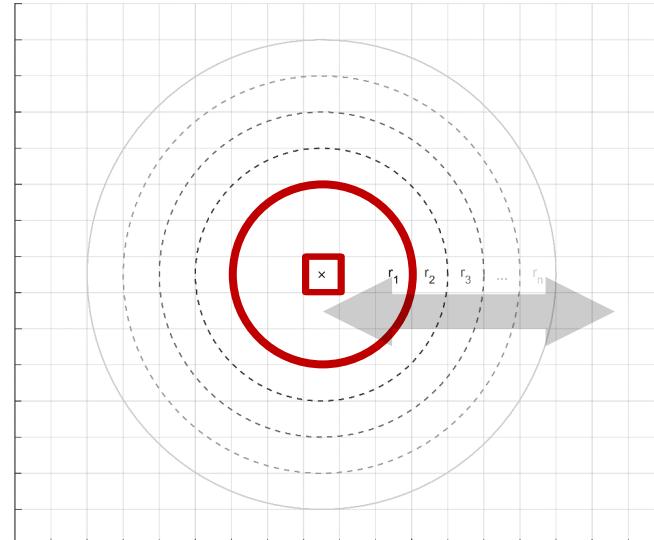
# Continuous Diversity Mapping

From Traits to Diversity

Moving-Window

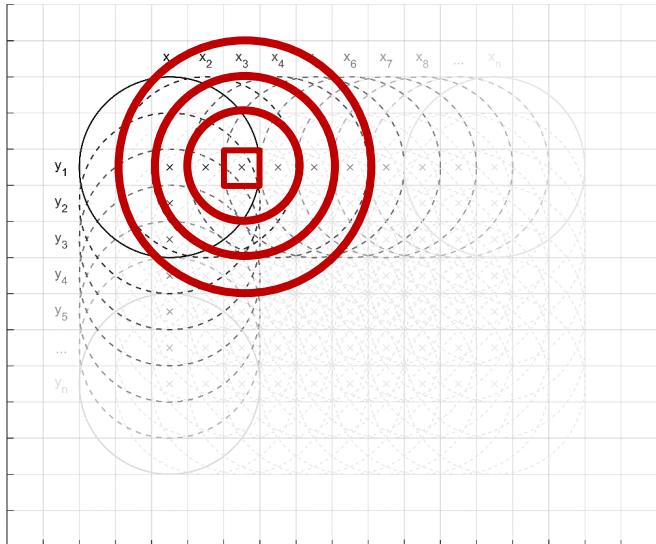


Radius

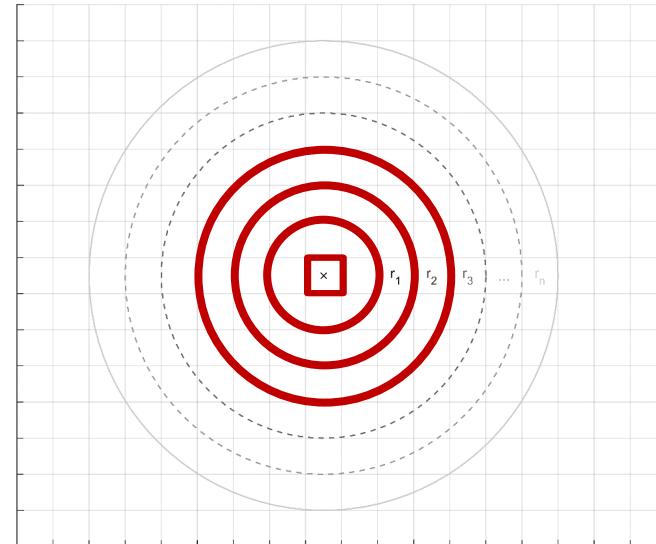


# Continuous Diversity Mapping

From Traits to Diversity



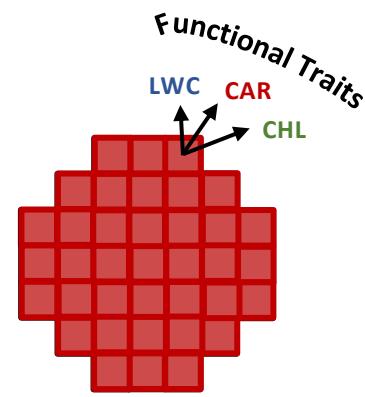
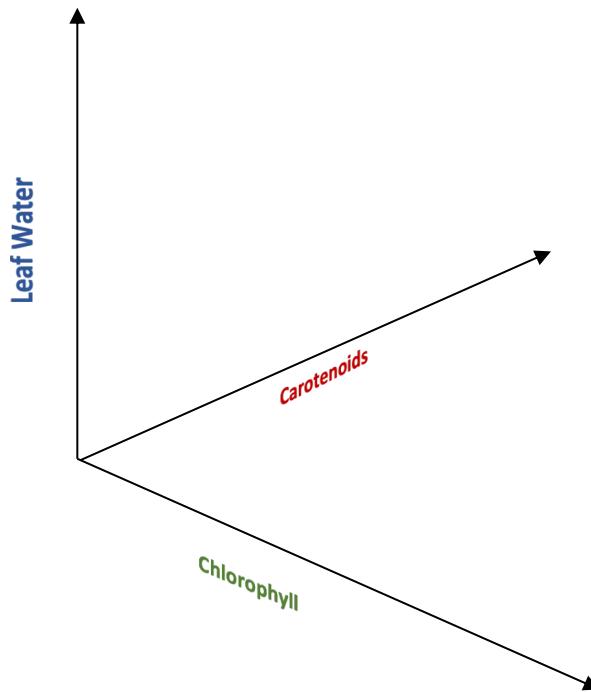
Radius



FD  
Area

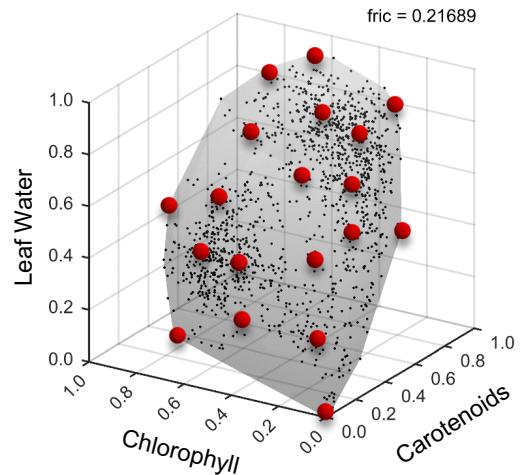
# Functional Diversity Measures

Analyzing the Trait Space

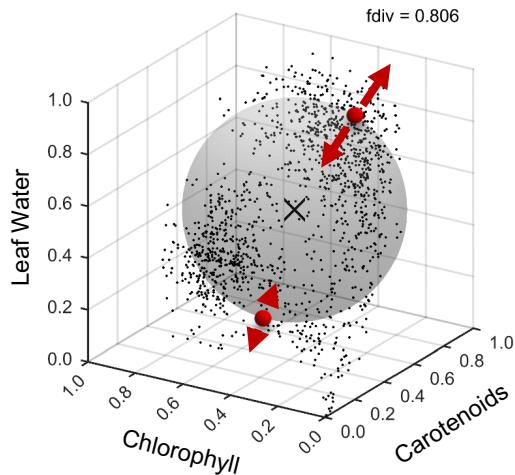


# Functional Diversity Measures

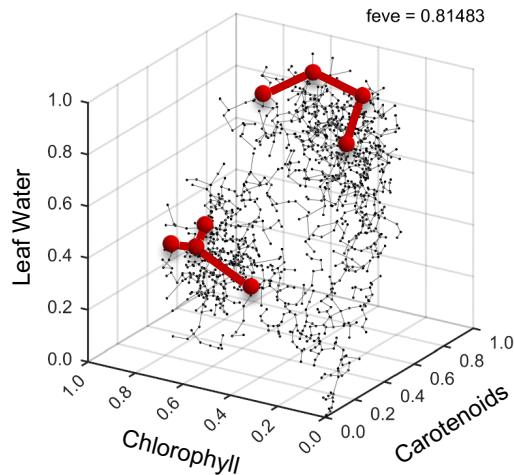
## Analyzing the Trait Space



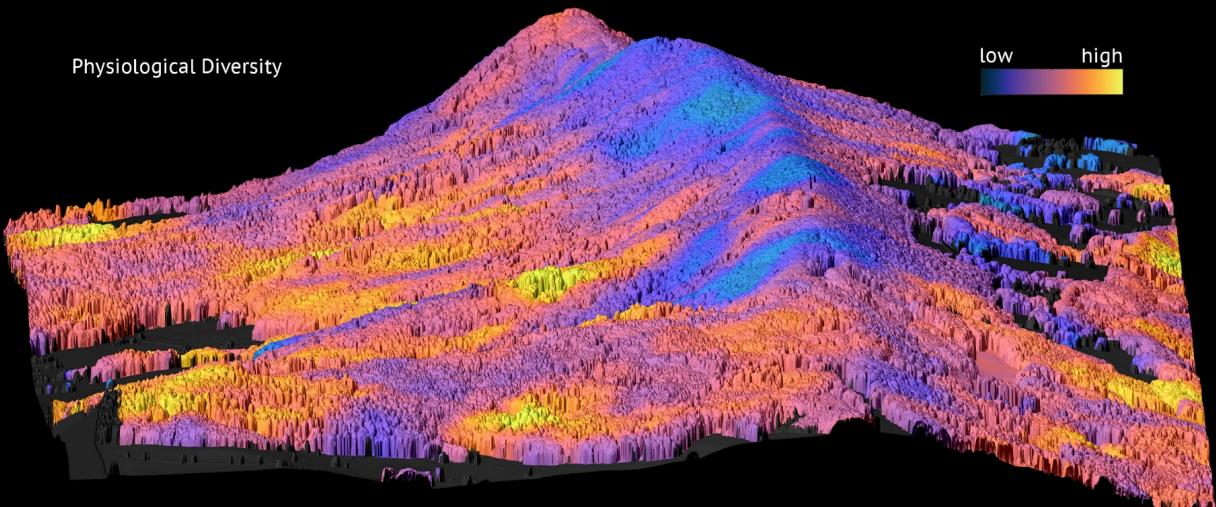
Functional Richness



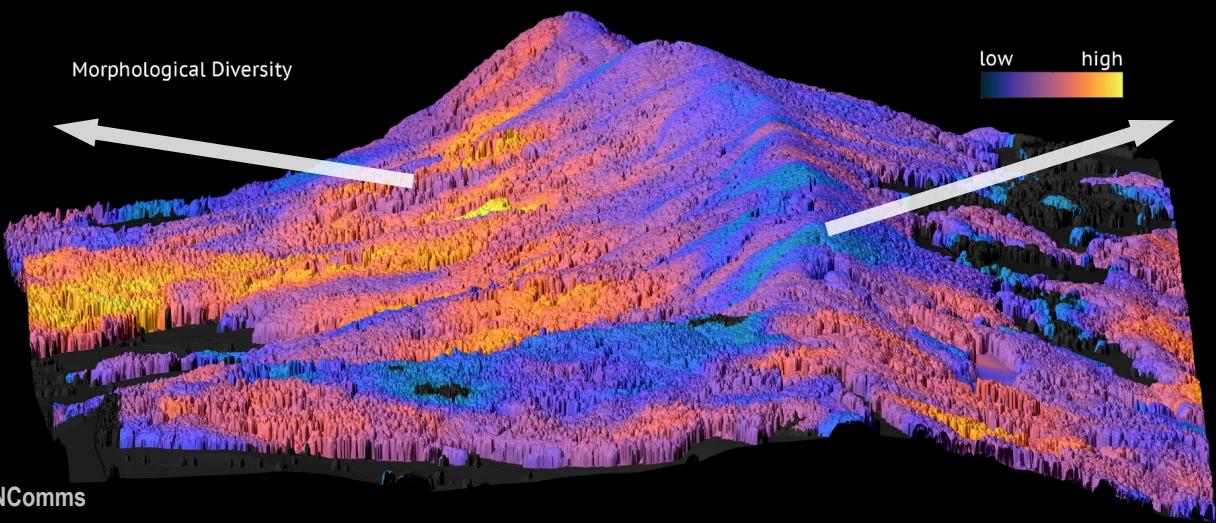
Functional Divergence



Functional Evenness



low high



low high

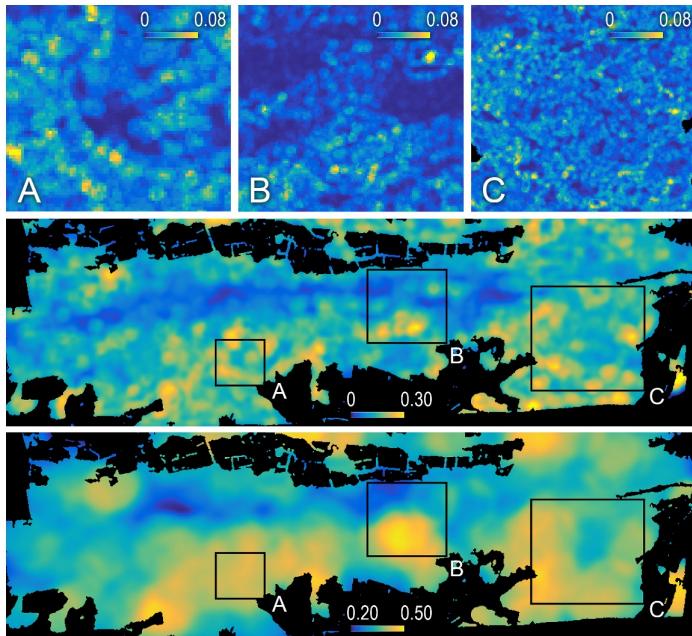


Photos: edaskliokys.ch, rainolo.ch

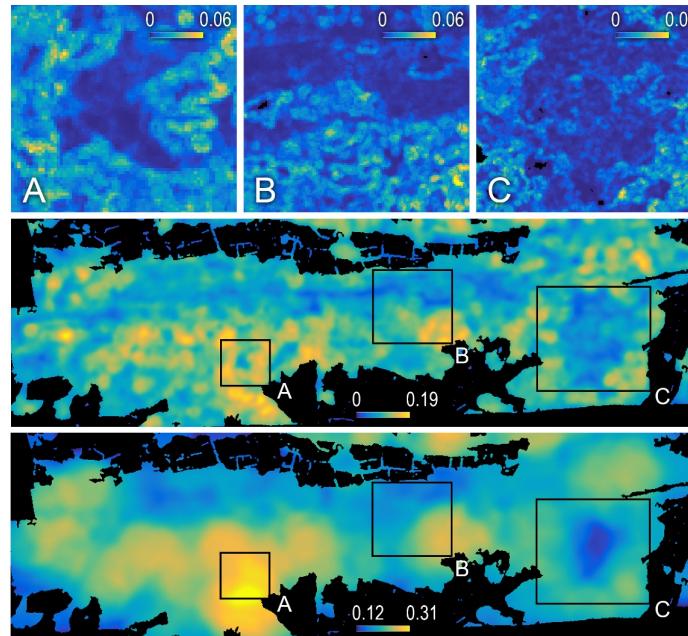
# Scale Dependence of Diversity

## Diversity-Area Relationship

Physiological Richness



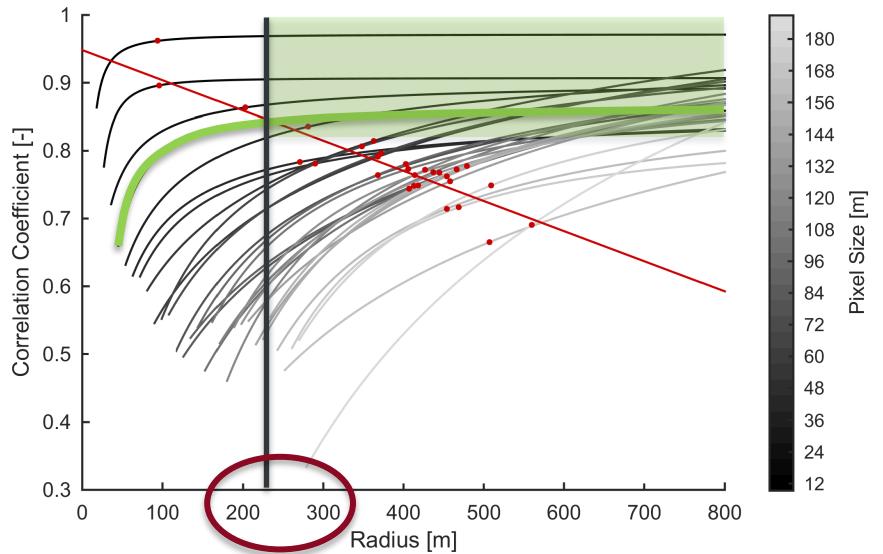
Morphological Richness



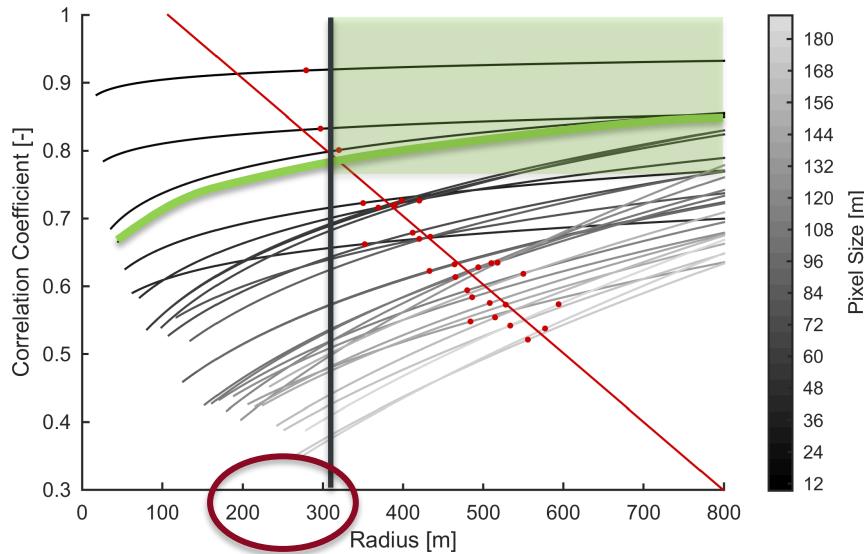
# Scale Dependence of Diversity

## Changing Grain and Extent

- Correlation to fine spatial grain, for...  
...morphological richness



- ...physiological richness



# Test Case in California

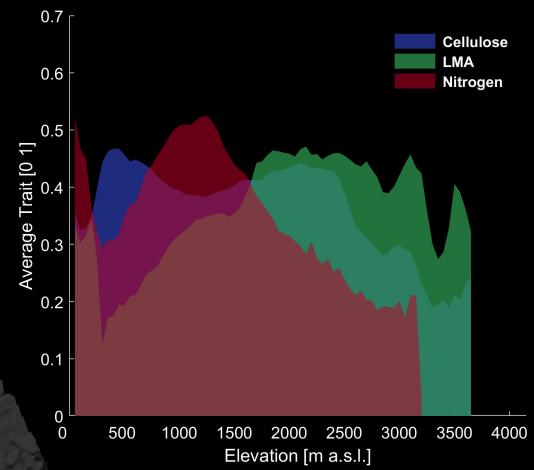
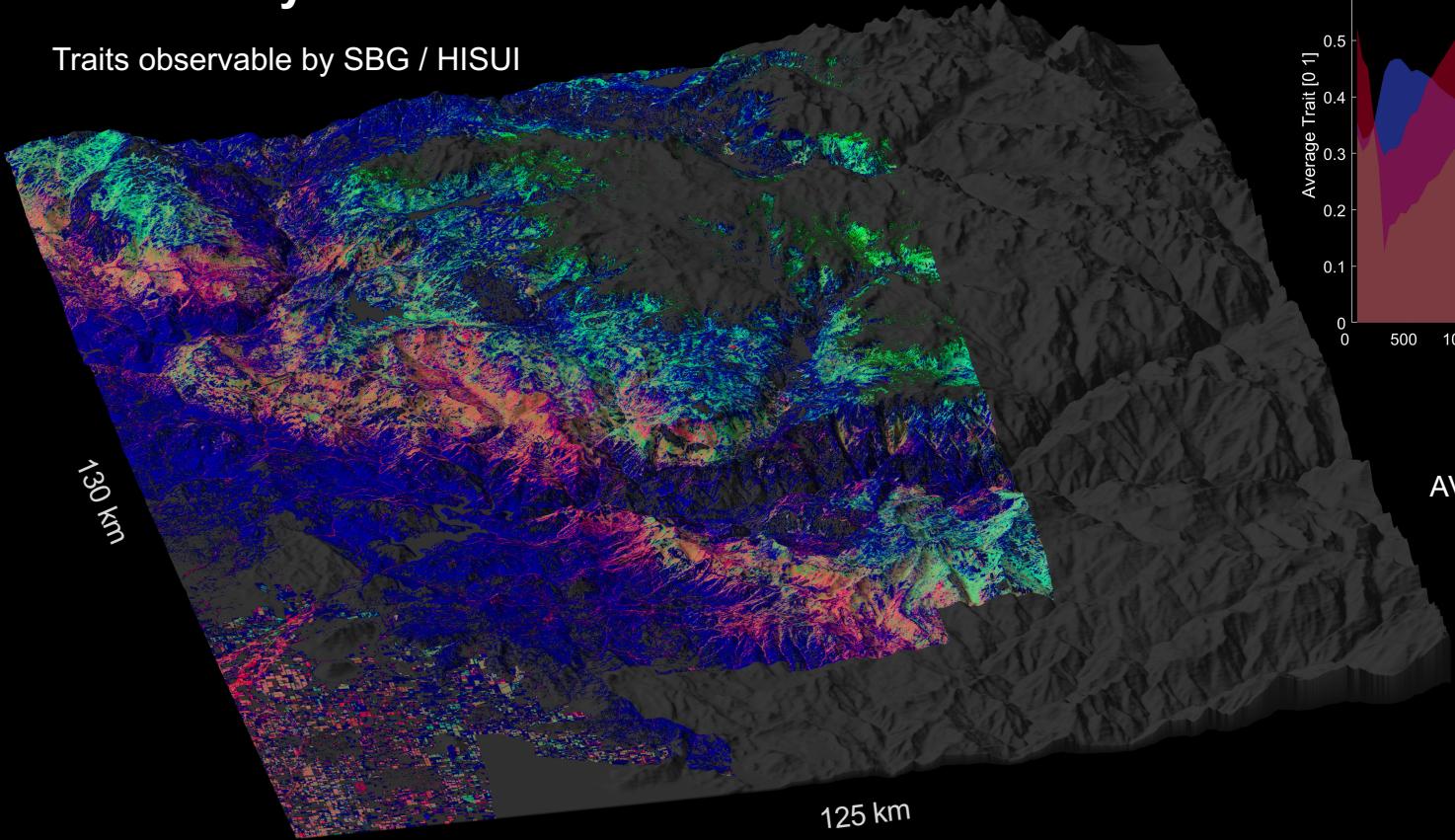
Large-Scale Airborne Data at Community Level



[https://upload.wikimedia.org/wikipedia/commons/0/d/Klamath-Canyon-National-Park\\_03.jpg](https://upload.wikimedia.org/wikipedia/commons/0/d/Klamath-Canyon-National-Park_03.jpg)

# Preliminary Results

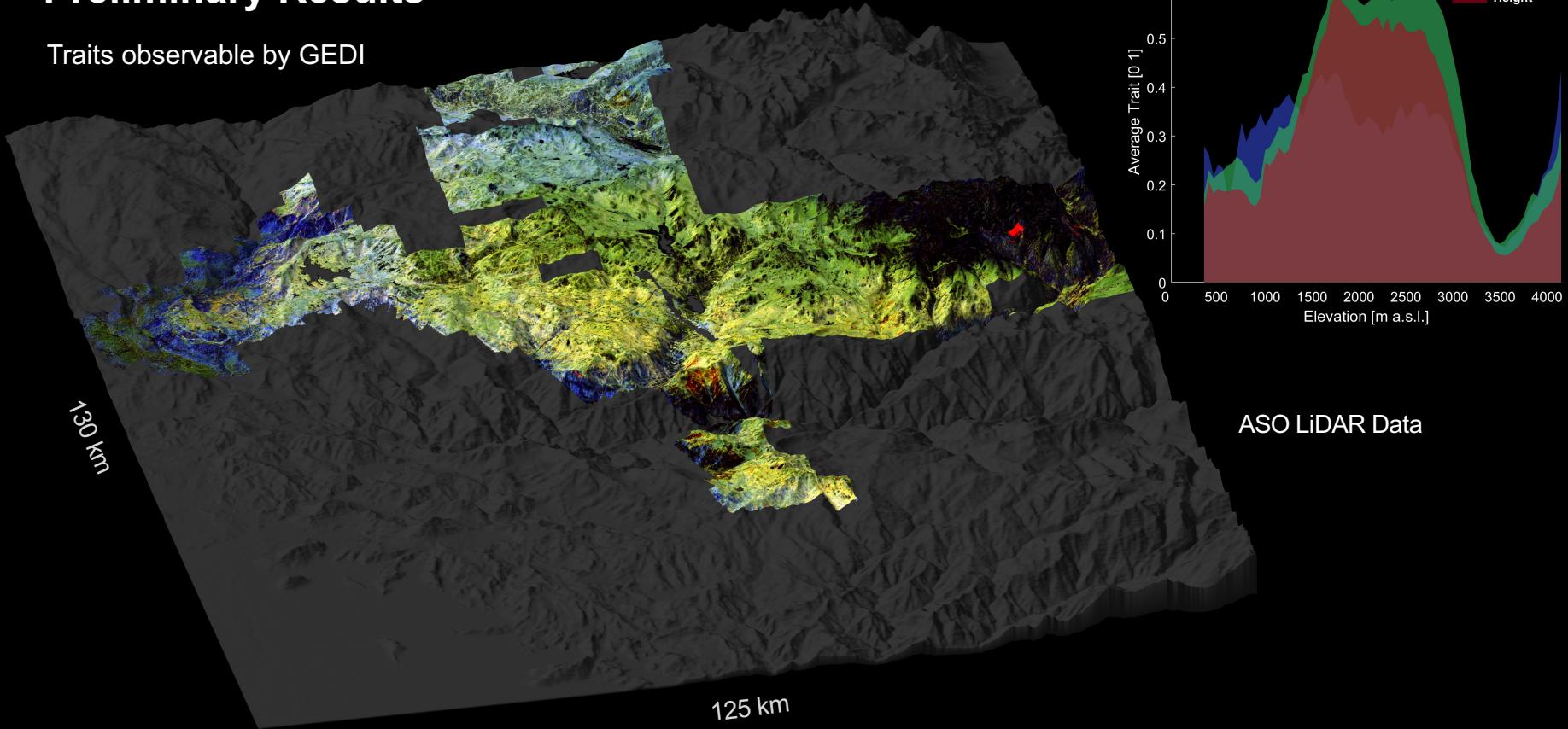
Traits observable by SBG / HISUI



AVIRIS Classic on ER-2

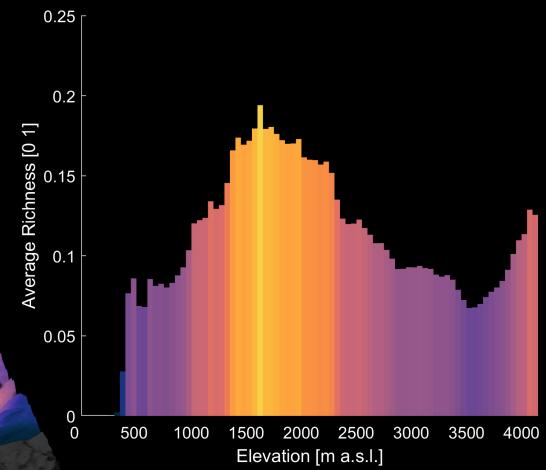
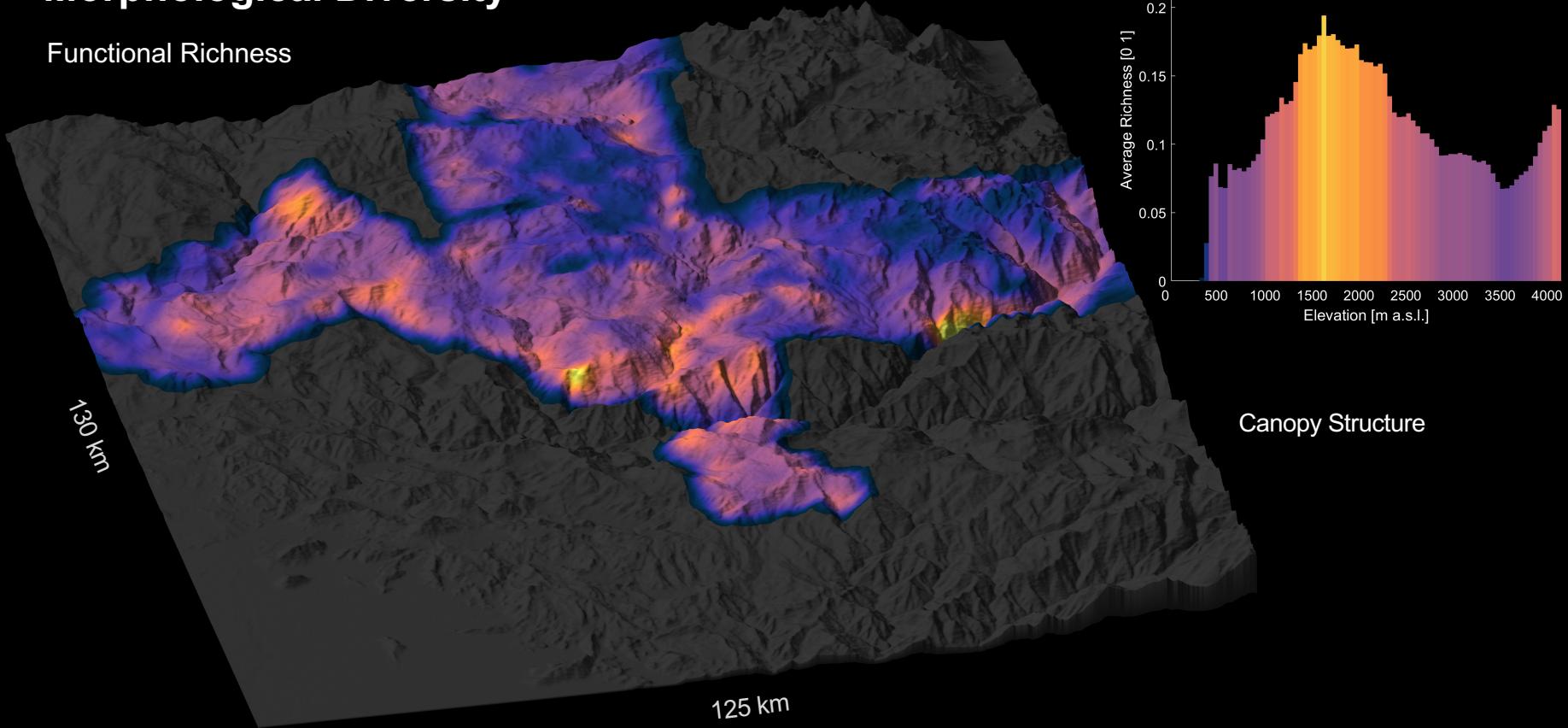
# Preliminary Results

Traits observable by GEDI



# Morphological Diversity

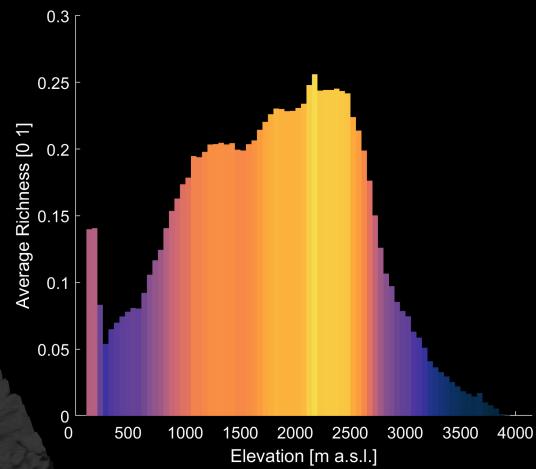
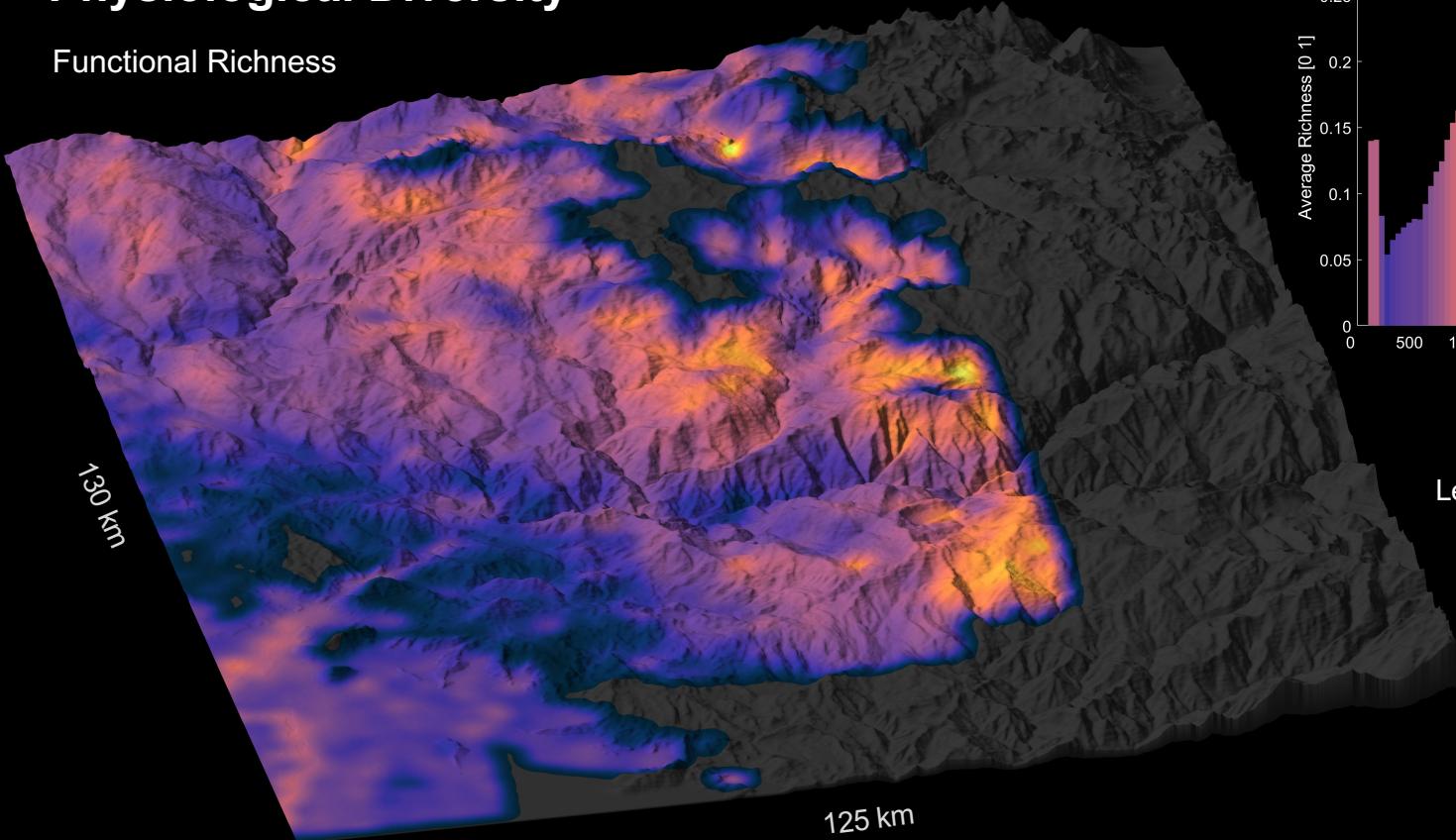
Functional Richness



Canopy Structure

# Physiological Diversity

Functional Richness

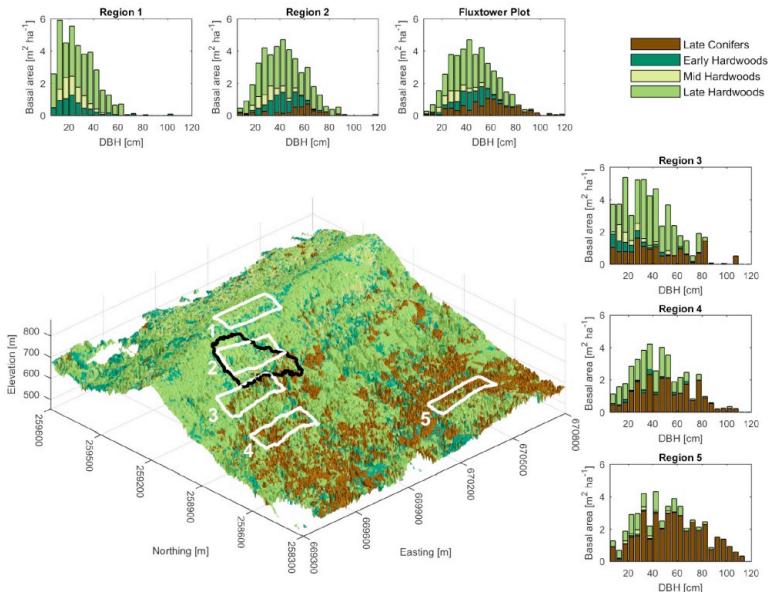


Leaf Physiology

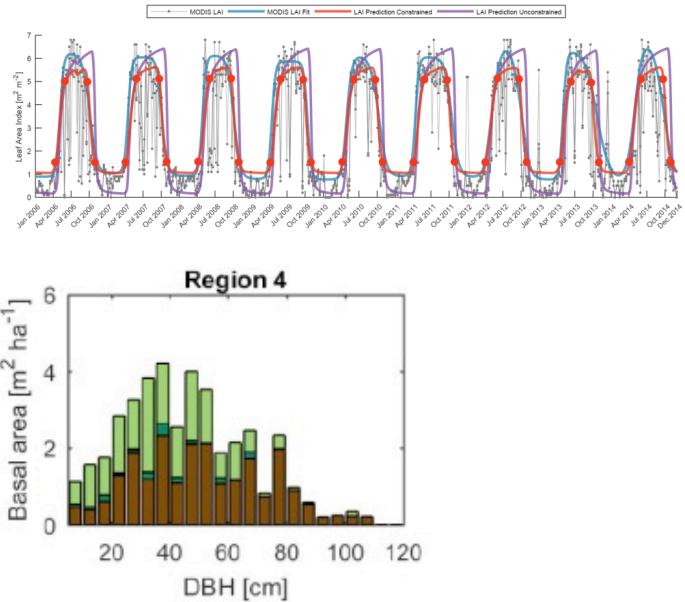
# From Diversity to Functioning

## Informing an Ecosystem Model with Remote Sensing Data

- Composition, Structure, Phenology



### Phenology

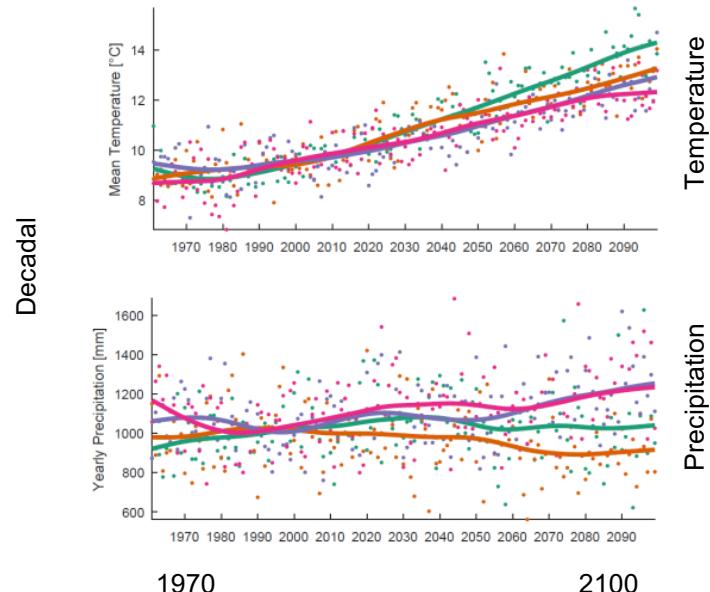
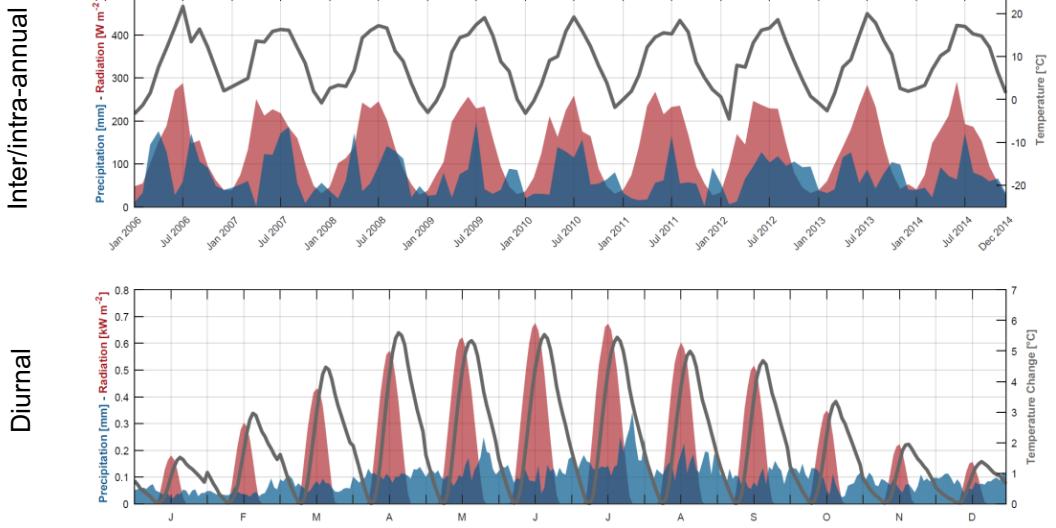


### Structure Composition

# From Diversity to Functioning

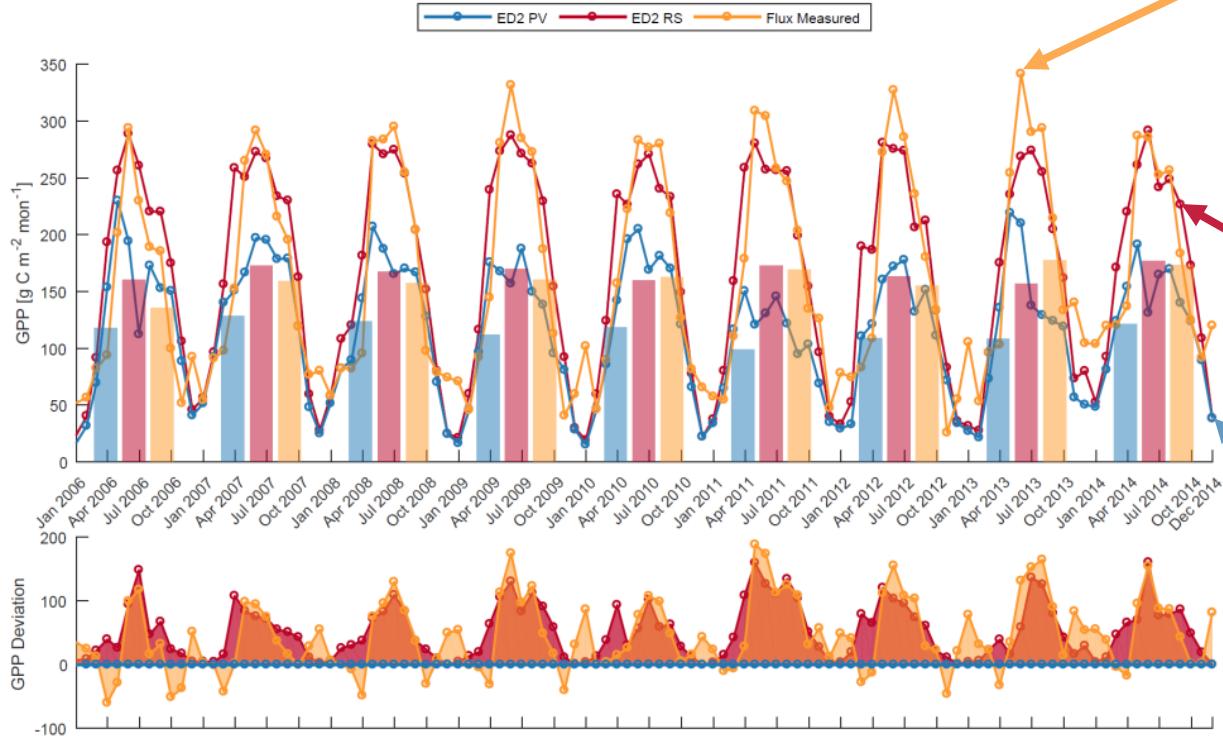
## Informing an Ecosystem Model with Remote Sensing Data

- Meteorological Drivers



# Predicting Carbon Uptake

RS Data to Improve Model Predictions in ED2

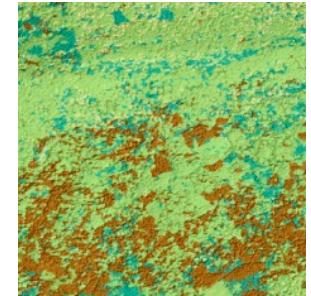


Fluxtower

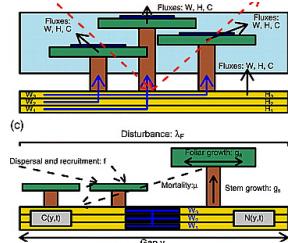


Photo: Reik Leiterer

RS informed



Uninformed  
model





# Conclusion

- Diversity mapping based on plant functional traits
  - Which traits are most relevant and how much of total diversity can be explained?
- Community-scale measurements from space
  - Airborne campaigns for scaling between in-situ and spaceborne measurements
- Link diversity patterns to ecosystem stability and productivity
  - Global biodiversity observatory
- Integration with ecosystem models
  - Wall-to-wall functional traits and trait diversity can help to improve modeling and predicting energy, water and carbon fluxes



# Thank you

Bernhard Schmid, Owen Petchey, Andy Hueni,  
David Thompson, Antonio Ferraz, Tom Painter,  
John Chapman, Adam Chlus, Zhiwei Ye



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